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CROP RESIDUES AS A BIO-ENERGY FEEDSTOCK: EFFECTS ON SOILS

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Crop Residue as a Bioenergy Feedstock: Effects on Soils

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February 16, 2006

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Fossil Fuel Alternatives Needed!

- National security
- Environmental concerns
- Renewable energy sources desired

Residue harvest:

- Improved conversion technology
- Inexpensive for energy plants
- Added farmer income
- Abundant in some systems

US Grain and Residue Production for Four Crops, 2000-2002 average

	Corn	Winter Wheat	Spring Wheat	Grain Sorghum
Grain (mill. bu)	9,477	1,357	488	452
Residue (mill. tons)	**265.3**	**69.2**	**19.0**	**13.5**
Energy (quads)	4.0	1.0	0.3	0.2

- Nelson, 2003

Residue Ecosystem Services

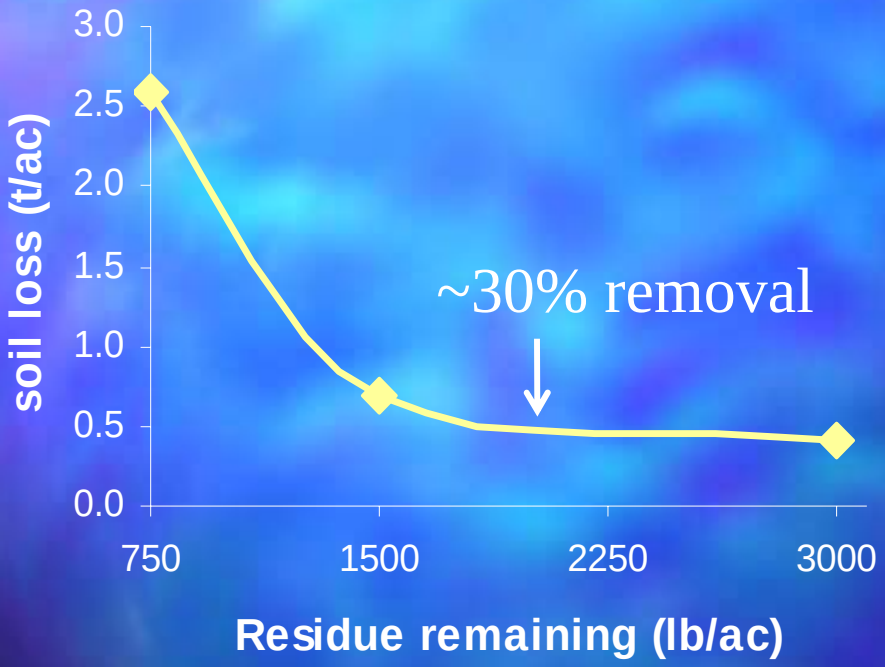
- Protection from soil erosion
- Increased soil organic matter (SOM) and plant-available nutrients
- Increased biological activity
- Increased yields

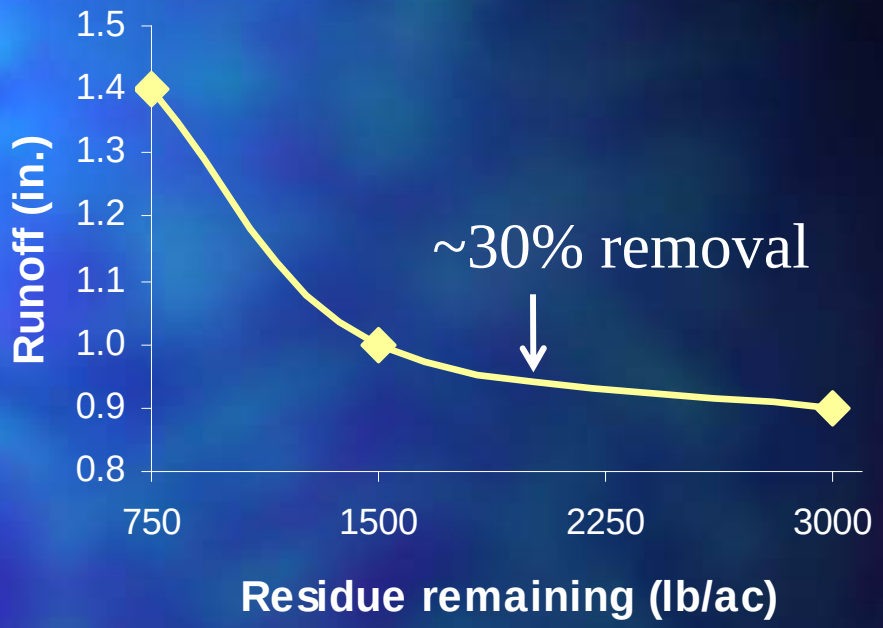
-after Hargrove, 1991

Presentation Overview

- Review research on soil effects
- Discuss recommendations
- Outline research needs

Residue Effects: Erosion





-after Lindstrom, 1986

This exact relationship varies with tillage & soil type

- Benoit and Lindstrom, 1987

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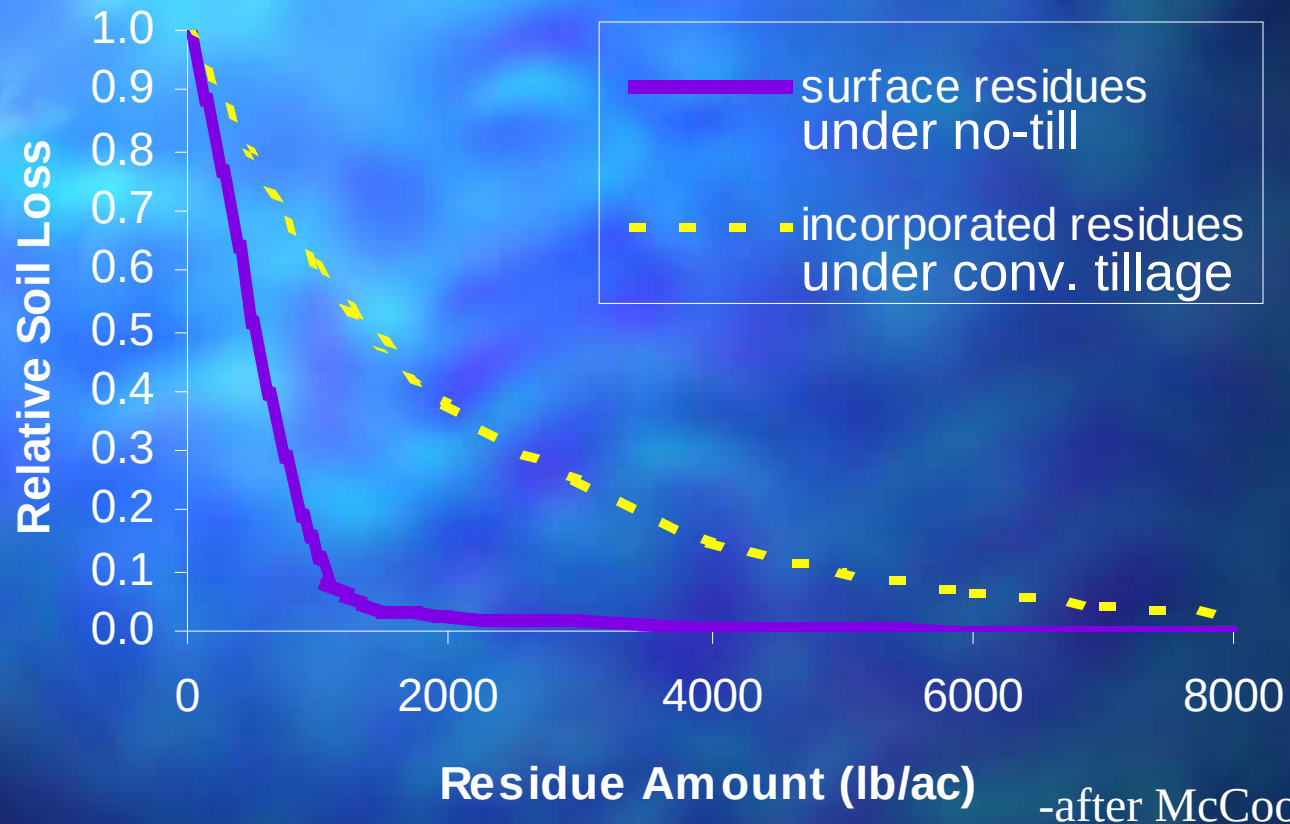
Residue Effects: Erosion



-after McCool et al., 1995

Residue removal requires conservation tillage!

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Residue Effects: SOM & Nutrients

- Net losses of soil nutrients when residue is removed
  –Holt, 1979; Lindstrom, 1986

- SOM higher with residue
  - under no-till
  - added N fertilizers

  -Reicosky et al., 2002
  -Dick et al., 1998
  -Clapp et al., 2000

- Cooler, drier climates allow more C accrual than warmer wetter ones
  –Potter et al. 1998

Residue Effects: Biological and Physical Effects

- Soil organisms
  - Reduced earthworms, microbes
    –Karlen et. al., 1984
  - Wildlife food & habitat -NRCS, 2004
  - Effects on soil pathogens vary
- Physical properties
  - higher bulk density -Clapp et al., 2000
  - lower aggregate stability -Karlen et al., 1994

Residue Effects: Yield

- Available Water
  - Residue increased water conservation, soil moisture
    -Power et al., 1986; Sauer et al, 1996
  - Higher yield in dry years with residue -Linden et al., 2000
- Soil Temperature
  - Lower soil temperatures decreased germination
    -Swan et al., 1987, Dam et al., 2005
  - Issue in poorly drained, fine textured soils
    -Benoit & Lindstrom, 1987

Other Effects: Economic Trade-offs

- Potential long-term yield loss
- More field passes & fuel use
- Opportunity Costs:
  - C trading
  - Conservation Programs
  - Other uses

Recommendations

- Guidelines for residue removal rates
- Additional Conservation Practices
- Alternative Crops
- Periodic monitoring and assessment

Removal Guidelines

Sustainable harvest amounts will vary by:

- Management practice → Increased soil disturbance
- Crop & yield → Lower yield or lower C:N
- Climate → Warmer, wetter climate
- Topography → Greater slope
- Soil type → Coarser soil texture

Harvest rates need to decrease with:

Potential Guideline Tools:

- Informational Tools
- USDA-NRCS Practice Standards
- Erosion Models (RUSLE2, WEQ, WEPP)
- Carbon models

  (Soil Conditioning Index - SCI)

Guidelines: Informational Tools

http://www.agr.gov.sk.ca/docs/econ_farm_man/production/cereals/mgtpractices.asp

Guidelines: USDA-NRCS Residue Management Practice Standards (329 a,b,c)

- Vary by tillage
- Use RUSLE2 & SCI

- Could include harvest maximums

Guidelines: Erosion Model Use

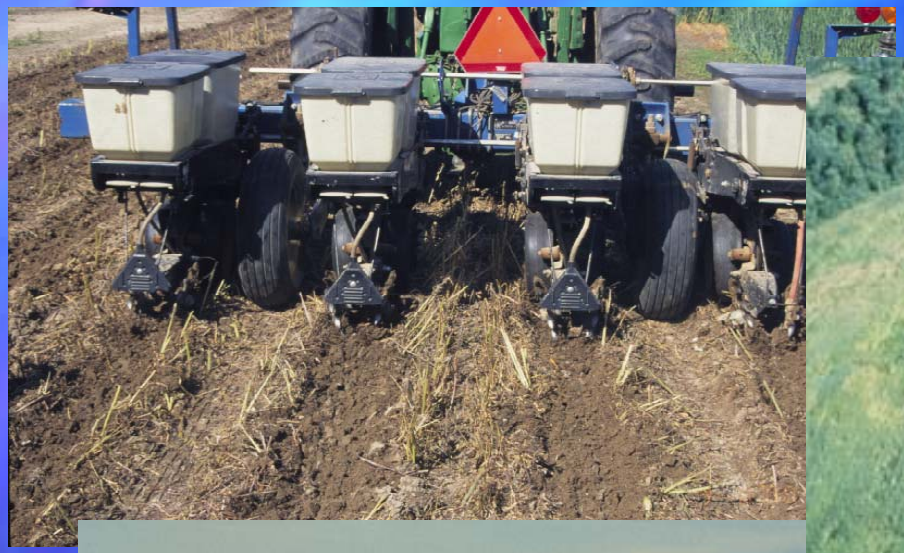
Nelson (2002):

- Criteria included meeting T
- Used RUSLE & WEQ
- Determined residue availability to be:
  - 43 million tonnes of corn stover
  - 8 million tonnes wheat straw
- Identified critical areas

Guidelines:
Soil Conditioning Index (SCI)

- Predicts organic matter trends
- Embedded in RUSLE2
- Based on three components
  - Organic material produced (or added)
  - Field Operations
  - Erosion

Additional Conservation Practices



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Alternative Crops

Dedicated energy crops:

- more environmentally benign
  -Giampietro et al., 1997
- Use perennials on marginal lands
  –Paine et al., 1996

Periodic monitoring & assessment

- Visual monitoring for increased erosion
- SOC checked as part of fertility tests
- Use adaptive management

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Research Needs

- Variable rate harvesters
- Systems modeling
  - Linking C-dynamics and soil erosion
  - Adding alternative practices
  - Validation!!!
- Monitor long-term removal effects

–Mann et al., 2002

- Continued research on dedicated, perennial bioenergy crops

Research Needs continued...

Guidelines for Residue Removal

- Simple decision aid
- Practical to apply
- Educational
- Based on crop, climate, soil and management

I speak for the SOILS!

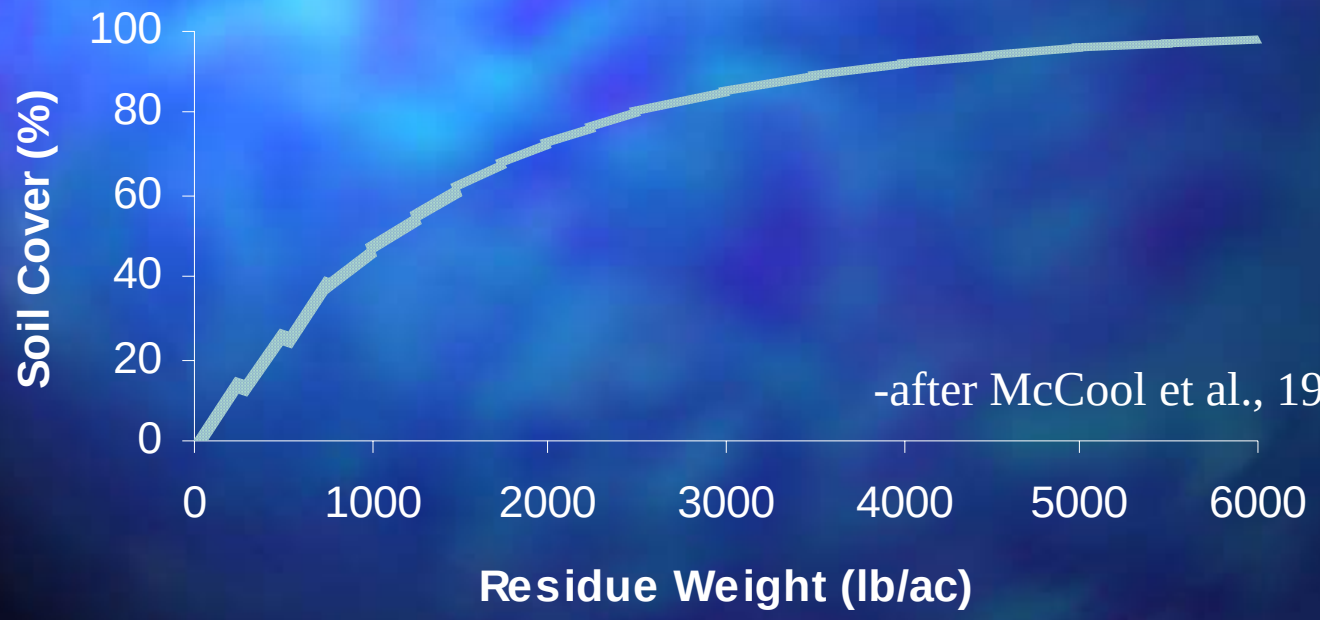
THE END

The Lorax

By Dr. Suess

Research Needs: Plant Data

% soil cover ≒ 100 - % removal rate



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Residue effect factors:

- Management
- Crop
- Climate
- Soil type
- Slope